The fish is 19·5 cm. in length (with caudal) and weighs 74 grms. It is interesting to note that, in spite of its totally wanting one pair of organs of locomotion, the specimen had, when caught, every appearance of being in as good condition and as well nourished as the normal fish of about equal size obtained from the same shoal, and most likely therefore of about the same age.

In connection with this case of abnormal absence of pelvic fins may be mentioned the fact that their *normal* absence among Teleostei is a much more frequent specific character than the absence of pectorals.

Day [1] mentions that pelvic fins were entirely absent in eleven out of thirteen specimens of *Gasterosteus pungitius* obtained by him in Ireland, and when present were very small. This abnormality was accompanied by modifications or absence of the pubic plate and ventral spine. In all the examples of *G. spinachia* and *G. aculeatus* pelvic fins were present.

I am indebted to Prof. G. B. Howes for a Goldfish, 7 cm. in length, in which the left pelvic fin is absent, the other being well developed. The abnormal Bream has been placed in the Museum of the Royal College of Surgeons.

DESCRIPTION OF PLATE X.

Fig. 1. Specimen without pelvic fins.
Fig. 2. Outline of normal fish.
Fig. 3. Ventral view of pelvic girdle and fins of 2.

5. Notes on the Osteology of *Heloderma horridum* and *H. suspectum*, with Remarks on the Systematic Position of the *Helodermatidæ* and on the Vertebræ of the Lacertilia.

By G. A. Boulenger.

[Received January 6, 1891.]

The skeleton of a fully adult specimen of *Heloderma horridum*, obtained by Dr. A. Buller in Mexico, has recently been prepared for exhibition in the galleries of the Natural History Museum, and at the same time Professor Stewart prepared a skeleton of an adult *H. suspectum* for the Museum of the Royal College of Surgeons. It appeared to me that it would be interesting on this occasion to make a comparison of the skeletons of the two species and to record whatever differences they might present; for although a good deal has been published on the osteology of *H. horridum* [2] and *H. suspectum* [3], no direct comparison of the two has yet been made.

[1] F. Day, "On some Irish Gasterostei," Journ. Linn. Soc., Zool. vol. xiii. 1878.

[2] Troschel, F. H. De Helodermate horrido. Orat. in facult. phil. Bonnensi. Bonn, 1851.
Troschel, F. H. Arch. f. Nat. 1853, p. 294, pls. xiii. & xiv.
Kaup, J. Arch. f. Nat. 1865, p 33, pl. iii.
Gervais, P. Journ. de Zool. ii. 1873, p. 453. pl. xii.

[3] Shufeldt, R. W. P. Z. S. 1890, p. 214, pls. xvii. & xviii.

With the kind aid of Professor Stewart, I have been able to bring together and compare the following material :—

H. horridum, Wiegm.

1. Adult ♀ skeleton from Salina Cruz, Mexico, obtained by Dr. A. Buller. In the British Museum.
2. Imperfect skull of a younger (half-grown) specimen from Mexico, extracted from an old skin. In the British Museum.

H. suspectum, Cope.

1. Adult ♀ skeleton. In the College of Surgeons.
2. Disarticulated skeleton, without the skull, of an adult ♂. In the College of Surgeons.
3. Right moiety of skull. In the British Museum.

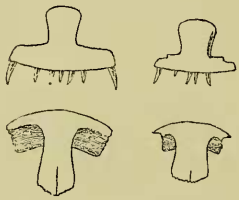
In the following notes I have limited myself to the skull and vertebral column[1], which have alone yielded specific differences, the other parts of the skeleton of the two species not differing in any important point, so far as I can see.

Skull.

The following characters distinguish the skulls of *H. horridum* and *H. suspectum* :—

In the latter, the oral portion of the præmaxillary is narrower, and its ascending internarial bar wider, than in the former—this

Fig. 1.



Præmaxillaries of *H. horridum* and *H. suspectum*.
Front view and upper view; nat. size.

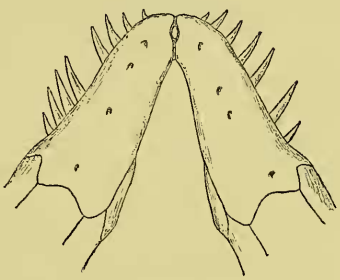
internarial bar measuring, at its narrowest point, one third instead of one fourth or one fifth of the greatest width of the bone. Eight or nine præmaxillary teeth are present in *H. horridum*, and only six in *H. suspectum*. Dr. Shufeldt, however, represents eight teeth in the latter species; but his figure, showing all the teeth as of the

[1] I must, however, remark that the number of phalanges is 2, 3, 4, 5, 3 in the manus, as correctly described by Shufeldt, whose figure, nevertheless, represents only four in the fourth finger, and 2, 3, 4, 5, 4 in the pes. Through terming the fifth metatarsal bone a tarsal, Shufeldt allows *Heloderma* but three phalanges in the fifth toe.

same size, looks very diagrammatic; the outer præmaxillary teeth are always larger than the median. The postorbital arch is more slender in *H. suspectum*. Palatine and pterygoid teeth appear to be constantly absent in *H. suspectum*, whereas they are present in both skulls of *H. horridum* examined by me as well as in those described by Troschel and by Kaup, who first noticed their presence. It is remarkable to find so important a difference between two species so closely allied. The presence of palatine teeth is quite exceptional among Lacertilia; they are only known in two other genera, viz., *Ophisaurus* and *Chamæleolis*. My adult specimen has six or seven teeth on each pterygoid and three on each palatine; the younger specimen has only one palatine and two pterygoid teeth on each side.

I was much surprised to find on the adult skull of *H. horridum* a small azygous ossification in the cartilage of the mandibular symphysis, apparently the homologue of the symphysial (mento-meckelian) bones of most tailless Batrachians. On referring to Dollo's paper on the skull of *Iguanodon* [1], I find that an apparently similar ossification has been noticed by Kölliker [2] in Man. Whether the præsymphysial bone (Dollo) of Dinosaurs is homologous with this is still questionable, especially since the discovery of a corresponding bone in the upper jaw, the "rostral bone" of Marsh [3]. The con-

Fig. 2.



Symphysial portion of mandible of *H. horridum*.
Lower view; nat. size.

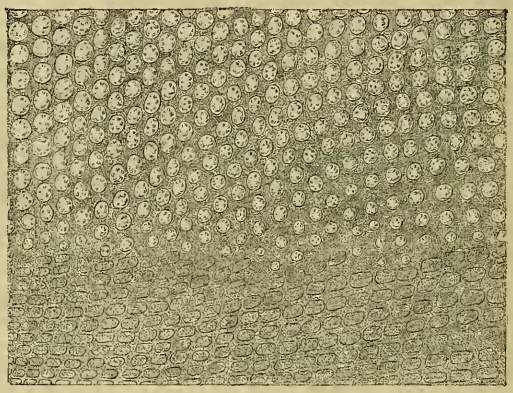
dition of this little bone in *Heloderma* appears to be very much the same as in Man, as far as may be judged from the few words devoted to it by Kölliker, and it is likewise only of exceptional occurrence, as I have failed to find a trace of it in any but this solitary specimen.

Another individual peculiarity of this same skull of *H. horridum* is the presence of a small tooth-like bony knob on the anterior portion of the under surface of the basioccipital, such as is often found,

[1] Bull. Mus. Belg. ii. 1883, p. 224.
[2] Entwickelungsgeschichte des Menschen, &c., 2nd ed. p. 473.
[3] Am. Journ. Sci. xxxix. 1890, pp. 81, 418.

more or less developed, in the Ophidians. As observed by Shufeldt, the bony dermal tubercles of the head are so intimately adherent to the bones that it is extremely difficult to remove them in adult specimens; but in the half-grown skull of *H. horridum*, which is quite as large as that of the adult *H. suspectum*, they could be detached very readily, and the skull shows all the sutures perfectly distinct, as correctly figured by Gervais and by Bocourt[1]. I may add that bony tubercles are also present on the dorsal and lateral

Fig. 3.



Skin of the middle part of the body of *H. suspectum*, epidermis removed, showing the bony tubercles; nat. size.

surfaces of the body, but wide apart and gradually diminishing in size towards the ventral surface, which is entirely devoid of dermal ossifications or shows mere ring-like traces of them, except on the præanal region, which, like the back, is studded with bony tubercles.

Vertebral Column.

This consists of 8 cervical, 26 dorsal, 2 sacral, and 40 caudal (=76) vertebræ in *H. horridum*, of 8 cervicals, 26 or 28 dorsals, 2 sacrals, and 27 caudals (=63 or 65) in *H. suspectum*. In the (♀) specimen of the latter species, with 28 dorsal vertebræ, both centrum and arch of the 21st vertebra are anchylosed with the 22nd.

I was anxious to examine the atlas, as I had been much struck by Dr. Shufeldt's statement (P. Z. S. 1890, p. 214) that it is "composed of five separate pieces; three of these are devoted to the formation of its anterior cup for the cranial condyle. Of these three pieces, one is a mid-ventral one, while either of the others are ventrolaterally situated. Each side of the neural arch is formed by one of the two of the remaining pieces of the five of the component elements of this vertebra: and in a large specimen of this lizard none

[1] Miss. Sc. Mex., Rept. pl. xx. E.

of these five parts had co-ossified." I can, however, now confidently affirm that Dr. Shufeldt has been deceived in his examination. The atlas-ring of *Heloderma* is formed, as in all Reptiles, of three pieces, a ventral and two dorso-lateral. The presence of five elements in the atlas-ring, if such had been the case, would have entirely upset the current view on the morphology of the vertebral column, which holds the said ring to be formed of the neural arch of the atlas and the proatlanto-atlantic hypapophysis or intercentrum; the centrum of the atlas being either free behind the ring or fused with the centrum of the vertebra following (odontoid process of the epistropheus). I regard the views held by Cope[1], Baur[2], and Credner[3] on the morphology of the vertebral column, based as they are on the evidence of the primitive structure afforded by many Stegocephalians, as thoroughly sound, and borne out by everything we know of the structure of recent and fossil Reptiles.

The vertebræ of Reptiles are composed of the following elements:—Neural arch (neurapophyses), centrum, and intercentrum (hypapophyses, subvertebral wedge-bones, chevrons). No Reptile shows an exogenous hypapophysis together with an autogenous hypapophysis, wedge-bone or chevron on the same centrum[4], and the continuity of the series of intercentral autogenous hypapophyses throughout the vertebral column, together with the gradual passage of the wedge-bones into the chevrons, is clearly exhibited in *Sphenodon* and the Geckos. The homology of the cervical hypapophyses with the chevrons is further manifested by such Squamata as have the chevrons attached to a single centrum, viz., the *Anguidæ*, *Varanidæ*, and *Mosasauridæ*, having the cervical hypapophyses likewise on the centrum; whilst those having the chevrons intercentral, viz., the *Agamidæ*, *Iguanidæ*, *Lacertidæ*, most *Scincidæ*, *Chamæleontidæ*, &c., have also the cervical hypapophyses so disposed.

In *Sphenodon* and Geckos, in which the branches of the anterior chevrons are united at the base, the hypapophysis anterior to the first chevron is single, but when the chevrons are V-shaped the hypapophysis preceding them is paired. Such is the case in *Heloderma*, and I have observed the same thing in many other Lizards, where these little bones bear much resemblance to the cervical hypapophyses of many Chelonians, or of *Lacerta agilis*, as figured by Leydig (Deutschl. Saur. pl. iv. fig. 53). I believe, however, that paired autogenous hypapophyses have not been recorded before in the caudal region of Lizards. The paired inferior processes of the caudal vertebræ of Snakes must be likewise regarded as homologous

[1] Amer. Nat. 1878, p. 327, and Tr. Am. Philos. Soc. (2) xvi. 1888, p. 243.
[2] Biol. Centralbl. vi. 1886, p. 332.
[3] Zeitschr. deutsch. geol. Ges. xlii. 1890, p. 260.
[4] Hulke (P. Z. S. 1888, p. 422) states that in the cervical vertebræ of *Trachydosaurus rugosus* "the '*intercalary*' or *intercentrum* coexists with a genuine [exogenous] *hypapophysis*;" but I have been unable to find any substantiation of this statement on a specimen of that Lizard in the College of Surgeons, which I have had especially cleaned for examining this point. It is possible that the part termed by Hulke *intercentrum* is an epiphysis of the hypapophysis such as is so well developed in *Varanus* and *Mosasauria*.

with the chevrons, especially if we look at the state of things in the anterior caudal region in the Mosasaurs, where we find distally disconnected paired hypapophyses, whether fused with the centrum (*Mosasaurus*)[1] or not (*Liodon*), passing into true chevrons.

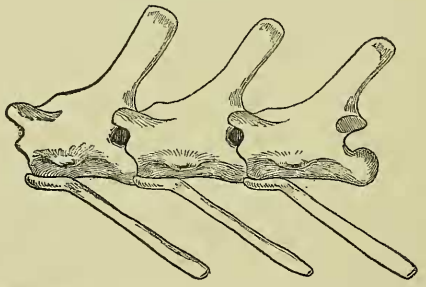
As to the term to be employed for the element under discussion, we have the choice between Owen's *hypapophysis*[2] and Cope's later *intercentrum*. The objection that may be made to the former term, of implying a process of the centrum, may be set aside from the fact that Owen himself intended it for auto- as well as exogenous formations, the two being, as far as Reptiles are concerned, certainly homologous—the exogenous hypapophyses of the cervical region of certain Lizards and Snakes, and of the caudal region of Snakes and certain Mosasaurians, being nothing but the primitively autogenous and intercentral elements (intercentra) shifted forwards or backwards as the case may be[3] and fused with the centrum. And Cope's term

[1] The chevrons are also anchylosed to the centrum in *Diploglossus* and *Ophisaurus*.

[2] The term *hæmapophysis* should be entirely discarded, as based on a theoretical conception which is not borne out by our present knowledge. The loose application of the term *hæmal spine* by Owen is best shown in one of his later papers (Quart. Journ. Geol. Soc. 1877, p. 709), where "*hæmal spine*" stands for the cervical hypapophysis of *Iguana*, the hypapophysial epiphysis of the cervical vertebræ of *Clidastes*, as well as for the chevrons. The denomination *hæmal crest* or *hæmal spine* should be restricted to such ventral outgrowths of the centra as the keel found in many Chelonians or the long process of the lumbar vertebræ of the Rabbit.

[3] On examining a large variety of skeletons of Lizards, it is obvious that the intercentral chevrons have in most cases been shifted forwards, as every passage can be found between the position they occupy in *Gecko* and *Iguana* on the one hand, and *Varanus* and *Mosasaurus* on the other. But in *Tupinambis*, a mem-

Fig. 4.

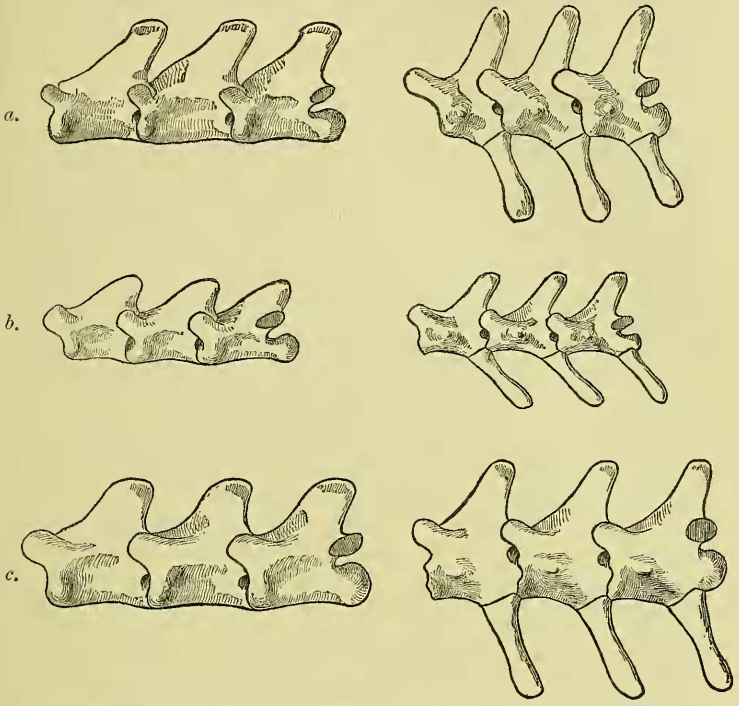


Caudal vertebræ of *Tupinambis nigropunctatus*; nat. size.

ber of the family *Teiidæ*, I find a very curious form of chevrons: the branches are in their proximal portion horizontal and applied against the centrum posterior to their intercentral attachment, the descending portion originating a little in advance of the middle of the centrum. We may easily imagine that such an arrangement may lead, by the fusion of the basal portion of the hypapophyses with the centrum, to a form of chevron comparable to that of a *Varanus*, but by a totally different process of evolution. By the way, it may be men-

may be likewise objected to on the ground that it is not expressive of the position assumed by the element in a great number of Reptiles.

Fig. 5.



Three posterior dorsal and three anterior caudal vertebræ of *Heloderma suspectum*, ♂ (*a*) and ♀ (*b*), and *H. horridum*, ♀ (*c*); nat. size.

I therefore think it best to retain the name *hypapophysis* (Owen), of which *intercentrum* (Cope) becomes a synonym.

Turning back again, after this somewhat lengthy digression, to the

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tioned that the zygosphenal articulation of the vertebræ exists in *Tupinambis* and *Teius* as in most *Iguanidæ*. Owen was mistaken in denying the existence of the zygosphene in *Amblyrhynchus*, where it is present as in most Iguanoids, including *Phrynosoma* and *Basiliscus*; only two Iguanoid genera are known to me to lack this additional articulation, viz., *Anolis* and *Polychrus*.

It appears to me very probable that the Lizards from the Eocene of Wyoming, described by Marsh (Am. Journ. (3) iv. 1872, p. 299) under the name of *Thinosaurus*, as having vertebræ resembling those of *Varanus*, but with zygosphenal articulation, belong to the family *Teiidæ*, and there can be no shadow of a doubt that the Cretaceous (Neocomian) *Hydrosaurus lesinensis* of Kornhuber (Abh. geol. Reichsanst. v. 1873, H. 4, pl. xx.), placed by Zittel in the *Varanidæ*, belongs to the *Dolichosauridæ*, possibly to the genus *Dolichosaurus* proper.

comparison of the vertebral columns of the two species of *Heloderma*, we have merely to notice the following differences:—A short rib is present on the third cervical in *H. horridum*, which is absent in *H. suspectum*; the neural spines are more elevated in the middle and posterior portion of the dorsal region in *H. horridum*, specimens of the same sex, of course, being compared. The neural spines are much more developed in the male.

Systematic Position of Heloderma.

That *Heloderma* is the type of a distinct family of Lizards is now universally admitted, but views differ as to its position in the system. The place of the *Helodermatidæ* between the *Anguidæ* and the *Varanidæ*, which I assigned to them in 1884, is, I still think, the most natural. They agree with the *Anguidæ* in the structure of the tongue and the presence of dermal ossifications[1], and it is probable that direct comparison of them with the numerous remains from the Eocene of Wyoming, described by Marsh (Am. Journ. (3) i. 1871, p. 456, and iv. 1872, pp. 302 and 305) as *Glyptosaurus*, would reveal their closer resemblance to these than to any of the existing members of that family. Marsh remarks of his *Glyptosaurus* that "the head was covered with large osseous shields, symmetrically arranged and highly ornamented, resembling in this respect the modern *Heloderma*." In *G. rugosus* "the prefrontal and postfrontal bones approach each other above the orbit."

The agreement with the *Varanidæ* is in the arrangement of the bones of the palate and the presence of descending laminæ of the frontals forming a bridge under the olfactory lobes of the brain (a character shown by the *Geckonidæ*, *Uroplatidæ*, *Eublepharidæ*, and Snakes[2]). Apart from the secondary character of the presence of grooves, the teeth of *Heloderma* resemble those of *Anguis* and *Varanus*. The most important character which differentiates *Heloderma* from all other Lizards is the presence of a bony postorbital arch, combined with the absence of a zygomatic arch. The absence of a transverse limb to the interclavicle is not of more than generic importance, as it occurs also in an Agamoid, *Lophura*, and the reverse modification, viz., the suppression of a longitudinal limb, in an Iguanoid, *Phrynosoma*.

The latest attempt at fixing the systematic position of *Heloderma* is Baur's[3] proposal to group the *Varanidæ*, *Mosasauridæ*, and *Helodermatidæ* together as follows:—

Platynota.	Varanoidea.....	*Varanidæ*.
		Mosasauridæ.
	Helodermatoidea....	*Helodermatidæ*.

[1] Through a printer's error, it is stated in my 'Catalogue of Lizards,' vol. ii. p. 266, that the dermal plates "are provided with a system of fine tubercles." *Tubercles* is so obviously a misprint for *tubules* that I should not have thought it worth while to correct the statement here but for the fact that it has been repeated in several recent palæontological works.

[2] But not by the Mosasaurs.

[3] Science, xvi. 1890, p. 262.

Although fully admitting the name *Pythonomorpha*[1] to have been ill chosen, I cannot but agree with Prof. Cope in maintaining the Mosasaurs as a suborder, if only for the hyperphalangy of their limbs[2] and the type of their dentition, the large osseous bases which bear the teeth being inserted in a groove of the jaws, a feature which may be regarded as midway between the thecodont and acrodont types; whereas the Monitors and Heloderms belong to the pleurodont type. The *Helodermatidæ* on the other hand are true Lacertilia, more closely related, in my opinion, to the *Anguidæ* than to the *Varanidæ*. And although there are undoubtedly many points common to the Monitors and the Mosasaurs, I hold that Dr. Baur is mistaken in proposing to revert to the Cuvierian views o the affinities of the large extinct marine Reptiles. Dr. Baur says: "It is evident that the *Mosasauridæ* are very closely related to the *Varanidæ*. They simply represent highly specialized aquatic forms." Does this mean that limbs so strongly specialized as those of the Monitors can have been modified into the paddles of the Mosasaurs? A glance at the figures (see fig. 6, p. 118) suffices to refute such a theory. But we can perfectly well conceive the hind limb of a Dolichosaurian becoming modified into the said paddle; and I can see no reason for not regarding these Cretaceous Lizards as the progenitors of the Mosasaurs, and at the same time of the true Lacertilia of which the Pleistocene and recent *Varanidæ* are a family. This view is besides in accordance with the suggestion made by Dollo[3], that the progenitors of the Mosasaurs must have possessed the zygosphenal articulation.

The Order Squamata may very well be divided into the following five Suborders, merely with regard to the structure of the limbs and vertebral column:—

A. Pectoral arch or its rudiments present. Caudal hypapophyses forming chevrons.
   I. *Dolichosauria.* 15–17 cervical vertebræ. Extremities (Fig. 6 A, p. 118) archaic, *i. e.*, approaching the Batrachian type.
   II. *Pythonomorpha.* 9 or 10 cervical vertebræ. Extremities (Fig. 6 B, p. 118) paddle-shaped, with hyperphalangy.
   III. *Lacertilia.* 8 or 9 cervical vertebræ. Fibula reduced proximally; fifth metatarsal reduced in length and strongly modified (Fig. 6 C, p. 118).
   IV. *Rhiptoglossa.* 5 cervical vertebræ. Extremities pincer-shaped; all the metatarsals reduced in length and strongly modified (Fig. 6 D, p. 118).
B. No trace of pectoral arch. Caudal hypapophyses disconnected distally.
   V. *Ophidia.*

[1] *Pythonomorpha*, Cope, 1869, = *Mosasauria*, Marsh, 1880.
[2] At least three phalanges in digit I.
[3] Bull. Soc. Belge Géol. iv. 1890, p. 167.

The probable affinities and phylogeny of these five groups are expressed by the following diagram:—

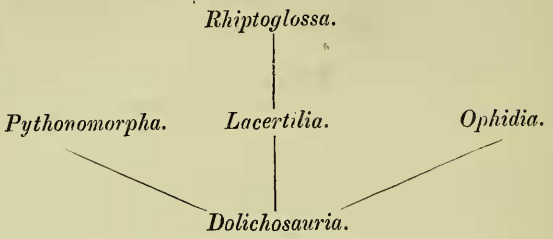
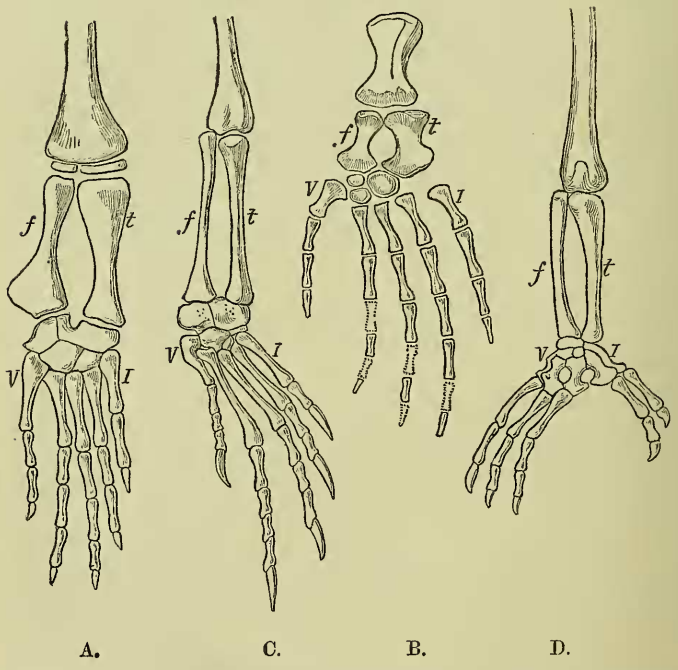


Fig. 6.



A. Hind limb of *Dolichosaurus lesinensis* (after Kornhuber); B. of *Edestosaurus* (after Marsh); C. of *Varanus*; D. of *Chamæleon*.

These figures illustrate the principal modifications of structure of the limbs in the four Suborders in which they are developed.